

## CLAIMS

1. A step-up apparatus comprising:

5 a first level shift circuit for receiving a  
first clock signal to generate two phase-opposite second clock  
signals;

a second level shift circuit for receiving  
said first clock signal to generate two phase-opposite third  
clock signals;

10 a charge pump circuit, connected to said first  
level shift circuit, for stepping up a power supply voltage  
at a power supply voltage terminal using said second clock  
signals to generate a positive voltage; and

15 a polarity inverting circuit, connected to  
said charge pump circuit and said second level shift circuit,  
for inverting said positive voltage using said third clock  
signals to generate a negative voltage whose absolute value  
is the same as said positive voltage,

20 a high level of said second clock signals being  
not higher than said positive voltage,

a low level of said second clock signals being  
not lower than a voltage at a ground terminal,

a high level of said third clock signals being  
not higher than said power supply voltage,

25 a low level of said third clock signals being  
not lower than said negative voltage.

2. The step-up apparatus as set forth in claim 1,  
wherein said first level shift circuit comprises:

30 first and second cross-coupled load P-channel  
MOS transistors whose sources receive said positive voltage;  
and

first and second N-channel drive MOS  
transistors whose drains are connected to drains of said first

and second cross-coupled load P-channel MOS transistors, respectively,

gates of said first and second N-channel drive MOS transistors receiving said first clock signal and its inverted signal, respectively,

the drains of said first and second N-channel drive MOS transistors generating said second clock signals.

3. The step-up apparatus as set forth in claim 1, wherein said second level shift circuit comprises:

first and second cross-coupled N-channel Load MOS transistors whose sources receive said voltage at said ground terminal; and

third and second P-channel drive MOS transistors whose sources receive said power supply voltage and whose drains are connected to drains of said first and second cross-coupled load N-channel MOS transistors, respectively,

gates of said first and second drive P-channel MOS transistors receiving said first clock signal and its inverted signal, respectively,

the drains of said first and second P-channel drive MOS transistors generating said third clock signals.

4. The step-up apparatus as set forth in claim 1, wherein said change pump circuit comprises:

a first circuit including a first step-up switching element, connected to said power supply voltage terminal, for generating said power supply voltage; and

an i-th ( $i=2, 3, \dots, K$ ) circuit including a charging capacitor, a first charging switching element connected between said ground terminal and said charging capacitor, a second charging element connected between said charging capacitor and said power supply voltage terminal, and a second step-up switching element connected to said charging

capacitor and said second charging switching element for generating an "i" times said power supply voltage.

5. The step-up apparatus as set forth in claim 4, wherein each of said first and second step-up switching elements comprises a P-channel MOS transistor controlled by one of said second clock signals,

said first charging switching element comprising an N-channel MOS transistor controlled by the one of said second clock signals,

10 said second charging switching element comprising a P-channel MOS transistor controlled by the other of said second clock signals.

6. The step-up apparatus as set forth in claim 1, wherein said charge pump circuit steps up said power supply voltage further using said third clock signals, said pump circuit comprising:

a first circuit including a first step-up switching element, connected to said power supply voltage terminal, for generating said power supply voltage; and

20 an i-th ( $i=2, 3, \dots, K$ ) circuit including a charging capacitor, a first charging switching element connected between said ground terminal and said charging capacitor, a second charging element connected between said charging capacitor and said power supply voltage terminal, and a second step-up switching element connected to said charging capacitor and said second charging switching element for generating an "i" times said power supply voltage,

30 said first step-up switching element comprising a P-channel MOS transistor controlled by one of said third clock signals,

said second charging switching element of said 2-nd circuit comprising a P-channel MOS transistor controlled by the other of said third clock signals,

said first charging switching element of said i-th (i= 2, 3, ...) circuit comprising an N-channel MOS transistor controlled by the one of said second clock signals,

5        said second charging switching element of said i-th (i= 3, 4, ...) circuit comprising a P-channel MOS transistor controlled by the other of said second clock signals,

10      said second step-up switching element comprising a P-channel MOS transistor controlled by the other of said second clock signal.

7.     A step-up apparatus comprising:

              a first level shift circuit for receiving a clock first signal to generate two phase-opposite second clock signals;

15      a second level shift circuit for receiving said first clock signal to generate a third clock signal;

              a charge pump circuit, connected to said first level shift circuit, for stepping up a power supply voltage at a power supply voltage terminal using said second clock signals to generate a positive voltage; and

20      a polarity inverting circuit, connected to said charge pump circuit and said second level shift circuit, for inverting said positive voltage using said third clock signal to generate a negative voltage whose absolute value is the same as said positive voltage,

25      a high level of said second clock signals being not higher than said positive voltage,

              a low level of said second clock signals being not lower than a voltage at a ground terminal,

30      a high level of said third clock signal being not higher than said voltage at said ground voltage,

              a low level of said third clock signal being not lower than said negative voltage.

8. The step-up apparatus as set forth in claim 7,  
wherein said first level shift circuit comprises:

first and second cross-coupled load P-channel  
MOS transistors whose sources receive said positive voltage;

5 and

first and second N-channel drive MOS  
transistors whose drains are connected to drains of said first  
and second cross-coupled load P-channel MOS transistors,  
respectively,

10 gates of said first and second N-channel drive  
MOS transistors receiving said first clock signal and its  
inverted signal, respectively,

the drains of said first and second N-channel  
drive MOS transistors generating said second clock signals.

15 9. The step-up apparatus as set forth in claim 7,  
wherein said second level shift circuit comprises:

a polarity inverting circuit for inverting  
said first clock signal;

20 first and second cross-coupled N-channel Load  
MOS transistors whose sources receive said negative voltage;  
and

25 third and second P-channel drive MOS  
transistors whose sources receive said voltage at said ground  
terminal and whose drains are connected to drains of said first  
and second cross-coupled load N-channel MOS transistors,  
respectively,

gates of said first and second drive P-channel  
MOS transistors receiving an output signal of said polarity  
inverting circuit and its inverted signal, respectively,

30 the drain of one of said first and second  
P-channel drive MOS transistors generating said third clock  
signal.

10. The step-up apparatus as set forth in claim 9,

wherein said polarity inverting circuit comprises a capacitor for receiving said first clock signal and a diode between said capacitor and said ground terminal.

11. The step-up apparatus as set forth in claim 7,  
5 wherein said charge pump circuit comprises:

a first circuit including a first step-up switching element, connected to said power supply voltage terminal, for generating said power supply voltage; and  
10 an i-th ( $i=2, 3, \dots, K$ ) circuit including a charging capacitor, a first charging switching element connected between said ground terminal and said charging capacitor, a second charging element connected between said charging capacitor and said power supply voltage terminal, and a second step-up switching element connected to said charging 15 capacitor and said second charging switching element for generating an "i" times said power supply voltage.

12. The step-up apparatus as set forth in claim 11,  
wherein each of said first and second step-up switching elements comprises a P-channel MOS transistor controlled by  
20 one of said second clock signals,

said first charging switching element comprising an N-channel MOS transistor controlled by the one of said second clock signals,

25 said second charging switching element comprising a P-channel MOS transistor controlled by the other of said second clock signals.

13. A step-up apparatus comprising:

a first level shift circuit for receiving a clock first signal to generate two phase-opposite second clock 30 signals;

a second level shift circuit for receiving said first clock signal to generate two phase-opposite third clock signals;

a charge pump circuit, connected to said first level shift circuit, for stepping up a power supply voltage at a power supply voltage terminal using said second clock signals to generate first and second positive voltages, said 5 first positive voltage being smaller than said second positive voltage; and

a polarity inverting circuit, connected to said charge pump circuit and said second level shift circuit, for inverting said second positive voltage using said third 10 clock signals to generate a negative voltage whose absolute value is the same as said second positive voltage,

a high level of said second clock signals being not higher than said second positive voltage,

15 a low level of said second clock signals being not lower than a voltage at a ground terminal,

a high level of said third clock signals being not higher than said power supply voltage,

a low level of said third clock signals being not lower than said negative voltage.

20 14. The step-up apparatus as set forth in claim 13, wherein said first level shift circuit comprises:

first and second cross-coupled load P-channel MOS transistors whose sources receive said second positive voltage; and

25 first and second N-channel drive MOS transistors whose drains are connected to drains of said first and second cross-coupled load P-channel MOS transistors, respectively,

gates of said first and second N-channel drive 30 MOS transistors receiving said first clock signal and its inverted signal, respectively,

the drains of said first and second N-channel drive MOS transistors generating said second clock signals.

15. The step-up apparatus as set forth in claim 13,  
wherein said second level shift circuit comprises:

first and second cross-coupled N-channel load  
MOS transistors whose sources receive said voltage as said  
5 ground terminal; and

third and second P-channel drive MOS  
transistors whose sources receive said power supply voltage  
and whose drains are connected to drains of said first and  
second cross-coupled load N-channel MOS transistors,  
10 respectively,

gates of said first and second drive P-channel  
MOS transistors receiving said first clock signal and its  
inverted signal, respectively,

the drains of said first and second P-channel  
15 drive MOS transistors generating said third clock signals.

16. The step-up apparatus as set forth in claim 13,  
wherein said charge pump circuit comprises:

a first circuit including a first step-up  
switching element, connected to said power supply voltage  
20 terminal, for generating said power supply voltage; and

an i-th ( $i=2, 3, \dots, K$ ) circuit including a  
charging capacitor, a first charging switching element  
connected between said ground terminal and said charging  
capacitor, a second charging element connected between said  
25 charging capacitor and said power supply voltage terminal, and  
a second step-up switching element connected to said charging  
capacitor and said second charging switching element for  
generating an "i" times said power supply voltage,

said L-th ( $L=2, 3, \dots, K-1$ ) circuit generating  
30 said first positive voltage,

said K-th ( $K > L$ ) circuit generating said  
second positive voltage.

17. The step-up apparatus as set forth in claim 16,

wherein each of said first and second step-up switching elements comprises a P-channel MOS transistor controlled by one of said second clock signals,

5           said first charging switching element comprising an N-channel MOS transistor controlled by the one of said second clock signals,

              said second charging switching element comprising a P-channel MOS transistor controlled by the other of said second clock signals.

10          18. The step-up apparatus as set forth in claim 13, wherein said charge pump circuit steps up said power supply voltage further using said third clock signals, pump circuit comprising:

15          a first circuit including a first step-up switching element, connected to said power supply voltage terminal, for generating said power supply voltage; and

20          an i-th ( $i=2, 3, \dots, K$ ) circuit including a charging capacitor, a first charging switching element connected between said ground terminal and said charging capacitor, a second charging element connected between said charging capacitor and said power supply voltage terminal, and a second step-up switching element connected to said charging capacitor and said second charging switching element for generating an "i" times said power supply voltage,

25          said first step-up switching element comprising a P-channel MOS transistor controlled by one of said third clock signals,

              said second charging switching element of said 2-nd circuit comprising a P-channel MOS transistor controlled by the other of said third clock signals,

              said first charging switching element of said i-th ( $i= 2, 3, \dots, K$ ) circuit comprising an N-channel MOS transistor controlled by the one of said second clock signals,

said second charging switching element of said i-th ( $i = 3, 4, \dots, K$ ) circuit comprising a P-channel MOS transistor controlled by the other of said second clock signals,

5               said second step-up switching element comprising a P-channel MOS transistor controlled by the other of said second clock signal,

              said L-th ( $L=2, 3, \dots, K-1$ ) circuit generating said first positive voltage,

10              said K-th ( $K > L$ ) circuit generating said second positive voltage.

19. A step-up apparatus comprising:

a first level shift circuit for receiving a clock first signal to generate two phase-opposite second clock signals;

15              a second level shift circuit for receiving said first clock signal to generate a third clock signal;

20              a charge pump circuit, connected to said first level shift circuit, for stepping up a power supply voltage at a power supply voltage terminal using said second clock signals to generate first and second positive voltages; and

25              a polarity inverting circuit, connected to said charge pump circuit and said second level shift circuit, for inverting said second positive voltage using said third clock signal to generate a negative voltage whose absolute value is the same as said second positive voltage,

              a high level of said second clock signals being not higher than said second positive voltage,

30              a low level of said second clock signals being not lower than a voltage at a ground terminal,

              a high level of said third clock signal being not higher than said voltage at said ground voltage,

              a low level of said third clock signal being

not lower than said negative voltage.

20. The step-up apparatus as set forth in claim 19, wherein said first level shift circuit comprises:

first and second cross-coupled load P-channel  
5 MOS transistors whose sources receive said second positive  
voltage; and

first and second N-channel drive MOS  
transistors whose drains are connected to drains of said first  
and second cross-coupled load P-channel MOS transistors,  
10 respectively,

gates of said first and second N-channel drive  
MOS transistors receiving said first clock signal and its  
inverted signal, respectively,

the drains of said first and second N-channel  
15 drive MOS transistors generating said second clock signals.

21. The step-up apparatus as set forth in claim 19, wherein said second level shift circuit comprises:

a polarity inverting circuit for inverting  
said first clock signal;

20 first and second cross-coupled N-channel Load  
MOS transistors whose sources receive said negative voltage;  
and

third and second P-channel drive MOS  
transistors whose sources receive said voltage at said ground  
25 terminal and whose drains are connected to drains of said first  
and second cross-coupled load N-channel MOS transistors,  
respectively,

gates of said first and second drive P-channel  
MOS transistors receiving an output signal of said polarity  
30 inverting circuit and its inverted signal, respectively,

the drain of one of said first and second  
P-channel drive MOS transistors generating said third clock  
signal.

22. The step-up apparatus as set forth in claim 21, wherein said polarity inverting circuit comprises a capacitor for receiving said first clock signal and a diode between said capacitor and said ground terminal.

5 23. The step-up apparatus as set forth in claim 19, wherein said charge pump circuit comprises:

a first circuit including a first step-up switching element, connected to said power supply voltage terminal, for generating said power supply voltage; and

10 an i-th ( $i=2, 3, \dots, K$ ) circuit including a charging capacitor, a first charging switching element connected between said ground terminal and said charging capacitor, a second charging element connected between said charging capacitor and said power supply voltage terminal, and 15 a second step-up switching element connected to said charging capacitor and said second charging switching element for generating an "i" times said power supply voltage,

said L-th ( $L=2, 3, \dots$ ) circuit generating said first positive voltage,

20 said K-th ( $K > L$ ) circuit generating said second positive voltage,

24. The step-up apparatus as set forth in claim 23, wherein each of said first and second step-up switching elements comprises a P-channel MOS transistor controlled by 25 one of said second clock signals,

said first charging switching element comprising an N-channel MOS transistor controlled by the one of said second clock signals,

30 said second charging switching element comprising a P-channel MOS transistor controlled by the other of said second clock signals.

25. A step-up apparatus comprising:

a first level shift circuit for receiving a

clock first signal to generate two phase-opposite second clock signals;

5        a second level shift circuit for receiving said first clock signal to generate two phase-opposite third clock signals;

10      a charge pump circuit, connected to said first level shift circuit, for stepping up a power supply voltage at a power supply voltage terminal using said second clock signals to generate first and second positive voltages, said first positive voltage being smaller than said second positive voltage; and

15      a polarity inverting circuit, connected to said charge pump circuit and said second level shift circuit, for inverting said first positive voltage using said third clock signals to generate a negative voltage whose absolute value is the same as said first positive voltage,

20      a high level of said second clock signals being not higher than said first positive voltage,

25      a low level of said second clock signals being not lower than a voltage at a ground terminal,

30      a high level of said third clock signals being not higher than said power supply voltage,

35      a low level of said third clock signals being not lower than said negative voltage.

40      26. The step-up apparatus as set forth in claim 25, wherein said first level shift circuit comprises:

45      first and second cross-coupled load P-channel MOS transistors whose sources receive said first positive voltage; and

50      first and second N-channel drive MOS transistors whose drains are connected to drains of said first and second cross-coupled load P-channel MOS transistors, respectively,

gates of said first and second N-channel drive MOS transistors receiving said first clock signal and its inverted signal, respectively,

5       the drains of said first and second N-channel drive MOS transistors generating said second clock signals.

27. The step-up apparatus as set forth in claim 25, wherein said second level shift circuit comprises:

10      first and second cross-coupled N-channel Load MOS transistors whose sources receive said voltage as said ground terminal; and

15      third and second P-channel drive MOS transistors whose sources receive said power supply voltage and whose drains are connected to drains of said first and second cross-coupled load N-channel MOS transistors, respectively,

20      gates of said first and second drive P-channel MOS transistors receiving said first clock signal and its inverted signal, respectively,

25      the drains of said first and second P-channel drive MOS transistors generating said third clock signals.

28. The step-up apparatus as set forth in claim 25, wherein said change pump circuit comprises:

25      a first circuit including a first step-up switching element, connected to said power supply voltage terminal, for generating said power supply voltage; and

30      an i-th ( $i=2, 3, \dots, L$ ) circuit including a charging capacitor, a first charging switching element connected between said ground terminal and said charging capacitor, a second charging element connected between said charging capacitor and said power supply voltage terminal, and a second step-up switching element connected to said charging capacitor and said second charging switching element for generating an "i" times said power supply voltage,

said K-th ( $K=2, 3, \dots, L-1$ ) circuit generating  
said first positive voltage,

                  said L-th ( $L > K$ ) circuit generating said  
second positive voltage.

5         29. The step-up apparatus as set forth in claim 28,  
wherein each of said first and second step-up switching  
elements comprises a P-channel MOS transistor controlled by  
one of said second clock signals,

10        said first charging switching element  
comprising an N-channel MOS transistor controlled by the one  
of said second clock signals,

                  said second charging switching element  
comprising a P-channel MOS transistor controlled by the other  
of said second clock signals.

15        30. The step-up apparatus as set forth in claim 25,  
wherein said charge pump circuit steps up said power supply  
voltage further using said third clock signals, said pump  
circuit comprising:

20        a first circuit including a first step-up  
switching element, connected to said power supply voltage  
terminal, for generating said power supply voltage; and

25        an i-th ( $i=2, 3, \dots, L$ ) circuit including a  
charging capacitor, a first charging switching element  
connected between said ground terminal and said charging  
capacitor, a second charging element connected between said  
charging capacitor and said power supply voltage terminal, and  
a second step-up switching element connected to said charging  
capacitor and said second charging switching element for  
generating an "i" times said power supply voltage,

30        said first step-up switching element  
comprising a P-channel MOS transistor controlled by one of  
said third clock signals,

                  said second charging switching element of said

2-nd circuit comprising a P-channel MOS transistor controlled by the other of said third clock signals,

5               said first charging switching element of said i-th ( $i = 2, 3, \dots, L$ ) circuit comprising an N-channel MOS transistor controlled by the one of said second clock signals,

              said second charging switching element of said i-th ( $i = 3, 4, \dots, L$ ) circuit comprising a P-channel MOS transistor controlled by the other of said second clock signals,

10              said second step-up switching element comprising a P-channel MOS transistor controlled by the other of said second clock signal,

              said K-th ( $K=2, 3, \dots, L-1$ ) circuit generating said first positive voltage,

15              said L-th ( $L > K$ ) circuit generating said second positive voltage.

31. A step-up apparatus comprising:

20              a first level shift circuit for receiving a clock first signal to generate two phase-opposite second clock signals;

              a second level shift circuit for receiving said first clock signal to generate a third clock signal;

25              a charge pump circuit, connected to said first level shift circuit, for stepping up a power supply voltage at a power supply voltage terminal using said second clock signals to generate first and second positive voltages; and

30              a polarity inverting circuit, connected to said charge pump circuit and said second level shift circuit, for inverting said first positive voltage using said third clock signal to generate a negative voltage whose absolute value is the same as said first positive voltage,

              a high level of said second clock signals being not higher than said first positive voltage,

a low level of said second clock signals being not lower than a voltage at a ground terminal,

a high level of said third clock signal being not higher than said voltage at said ground voltage,

5 a low level of said third clock signal being not lower than said negative voltage.

32. The step-up apparatus as set forth in claim 31, wherein said first level shift circuit comprises:

first and second cross-coupled load P-channel  
10 MOS transistors whose sources receive said first positive voltage; and

first and second N-channel drive MOS transistors whose drains are connected to drains of said first and second cross-coupled load P-channel MOS transistors,  
15 respectively,

gates of said first and second N-channel drive MOS transistors receiving said first clock signal and its inverted signal, respectively,

the drains of said first and second N-channel drive MOS transistors generating said second clock signals.  
20

33. The step-up apparatus as set forth in claim 31, wherein said second level shift circuit comprises:

a polarity inverting circuit for inverting said first clock signal;  
25 first and second cross-coupled N-channel Load MOS transistors whose sources receive said negative voltage; and

third and second P-channel drive MOS transistors whose sources receive said voltage at said ground terminal and whose drains are connected to drains of said first and second cross-coupled load N-channel MOS transistors,  
30 respectively,

gates of said first and second drive P-channel

MOS transistors receiving an output signal of said polarity inverting circuit and its inverted signal, respectively,  
the drain of one of said first and second  
P-channel drive MOS transistors generating said third clock  
5 signal.

34. The step-up apparatus as set forth in claim 33,  
wherein said polarity inverting circuit comprises a capacitor  
for receiving said first clock signal and a diode between said  
capacitor and said ground terminal.

10 35. The step-up apparatus as set forth in claim 31,  
wherein said charge pump circuit comprises:

a first circuit including a first step-up  
switching element, connected to said power supply voltage  
terminal, for generating said power supply voltage; and

15 an i-th ( $i=2, 3, \dots, L$ ) circuit including a  
charging capacitor, a first charging switching element  
connected between said ground terminal and said charging  
capacitor, a second charging element connected between said  
charging capacitor and said power supply voltage terminal, and  
20 a second step-up switching element connected to said charging  
capacitor and said second charging switching element for  
generating an "i" times said power supply voltage,

said K-th ( $K=2, 3, \dots$ ) circuit generating said  
first positive voltage,

25 said L-th ( $L > K$ ) circuit generating said  
second positive voltage,

36. The step-up apparatus as set forth in claim 35,  
wherein each of said first and second step-up switching  
elements comprises a P-channel MOS transistor controlled by  
30 one of said second clock signals,

said first charging switching element  
comprising an N-channel MOS transistor controlled by the one  
of said second clock signals,

said second charging switching element comprising a P-channel MOS transistor controlled by the other of said second clock signals.

37. A step-up apparatus comprising:

5           a first level shift circuit for receiving a first clock signal to generate a 2nd clock signal, a 3rd clock signal, ..., a K-th clock signal ( $K = 2, 3, \dots$ ) having a definite voltage swing;

10          a second level shift circuit for receiving said first clock signal to generate two phase-opposite third clock signals;

15          a charge pump circuit, connected to said first level shift circuit, for stepping up a power supply voltage at a power supply voltage terminal using said first, second, ..., K-th clock signals to generate a positive voltage; and

20          a polarity inverting circuit, connected to said charge pump circuit and said second level shift circuit, for inverting said positive voltage using said third clock signals to generate a negative voltage whose absolute value is the same as said positive voltage,

38. The step-up apparatus as set forth in claim 37, wherein said change pump circuit comprises:

25          a first circuit including a first step-up switching element, connected to said power supply voltage terminal, for generating said power supply voltage in accordance with said first clock signal;

30          an i-th ( $i = 2, 3, \dots, K$ ) circuit including a charging capacitor, a first charging switching element connected between said ground terminal and said charging capacitor, a second charging element connected between said charging capacitor and said power supply voltage terminal, and a second step-up switching element connected to said charging capacitor and said second charging switching element for

generating an "i" times said power supply voltage.

39. The step-up apparatus as set forth in claim 38, wherein said first step-up switching element comprises a P-channel MOS transistor controlled by said first clock signal,

said first charging switching element comprising an N-channel MOS transistor controlled by said first clock signal,

10 said second charging switching element comprising an N-channel MOS transistor controlled by said second clock signal,

said second step-up switching element of said i-th ( $i = 2, 3, \dots, K$ ) circuit comprising a P-channel MOS transistor controlled by said i-th clock signal.

15 40. The step-up apparatus as set forth in claim 38, wherein said first level shift circuit comprises an i-th ( $i = 2, 3, \dots, K$ ) level shift unit is powered by  $(i-2) \cdot V_{DD}$ ,  $(i-1) \cdot V_{DD}$  and  $i \cdot V_{DD}$  where  $V_{DD}$  is a power supply voltage.

41. The step-up apparatus as set forth in claim 40,  
20 wherein said i-th level shift unit comprises:

cross-coupled first and second load N-channel MOS transistors whose sources receive  $(i-2) \cdot V_{DD}$ ;

25 first and second drive P-channel MOS transistors whose sources receive  $(i-1) \cdot V_{DD}$  and whose drains are connected to drains of said first and second load N-channel MOS transistors, respectively;

cross-coupled first and second load P-channel MOS transistors whose sources receive  $i \cdot V_{DD}$ ; and

30 first and second drive N-channel MOS transistors whose sources receive  $(i-2) \cdot V_{DD}$ , whose drains are connected to drains of said first and second load P-channel MOS transistors, respectively, and whose gates are connected to gates of said first and second load N-channel MOS

transistors, respectively,

gates of said first and drive P-channel MOS transistors receiving said (i-1)-th clock signal and its inverted signal,

5 the drain of said second drive N-channel MOS transistor generating said i-th clock signal via an inverter.

42. A step-up apparatus comprising:

a level shift circuit for receiving a first clock signal to generate a 2nd clock signal, a 3rd clock signal, 10 ..., a K-th clock signal ( $K = 2, 3, \dots$ ) having a definite voltage swing; and

15 a charge pump circuit, connected to said first level shift circuit, for stepping up a power supply voltage at a power supply voltage terminal using said first, second, ..., K-th clock signals to generate a positive voltage.

43. The step-up apparatus as set forth in claim 42, wherein said charge pump circuit comprises:

20 a first circuit including a first step-up switching element, connected to said power supply voltage terminal, for generating said power supply voltage in accordance with said first clock signal;

25 an i-th ( $i = 2, 3, \dots, K$ ) circuit including a charging capacitor, a first charging switching element connected between said ground terminal and said charging capacitor, a second charging element connected between said charging capacitor and said power supply voltage terminal, and a second step-up switching element connected to said charging capacitor and said second charging switching element for generating an "i" times said power supply voltage.

30 44. The step-up apparatus as set forth in claim 43, wherein said first step-up switching element comprises a P-channel MOS transistor controlled by said first clock signal,

said first charging switching element comprising an N-channel MOS transistor controlled by said first clock signal,

5        said second charging switching element comprising an N-channel MOS transistor controlled by said second clock signal,

              said second step-up switching element of said i-th ( $i = 2, 3, \dots, K$ ) circuit comprising a P-channel MOS transistor controlled by said i-th clock signal.

10      45. The step-up apparatus as set forth in claim 43, wherein said level shift circuit comprises an i-th ( $i = 2, 3, \dots, K$ ) level shift unit is powered by  $(i-2) \cdot V_{DD}$ ,  $(i-1) \cdot V_{DD}$  and  $i \cdot V_{DD}$  where  $V_{DD}$  is a power supply voltage.

15      46. The step-up apparatus as set forth in claim 45, wherein said i-th level shift unit comprises:

              cross-coupled first and second load N-channel MOS transistors whose sources receive  $(i-2) \cdot V_{DD}$ ;

20      first and second drive P-channel MOS transistors whose sources receive  $(i-1) \cdot V_{DD}$  and whose drains are connected to drains of said first and second load N-channel MOS transistors, respectively;

              cross-coupled first and second load P-channel MOS transistors whose sources receive  $i \cdot V_{DD}$ ; and

25      first and second drive N-channel MOS transistors whose sources receive  $(i-2) \cdot V_{DD}$ , whose drains are connected to drains of said first and second load P-channel MOS transistors, respectively, and whose gates are connected to gates of said first and second load N-channel MOS transistors, respectively,

30      gates of said first and drive P-channel MOS transistors receiving said  $(i-1)$ -th clock signal and its inverted signal,

              the drain of said second drive N-channel MOS

transistor generating said i-th clock signal via an inverter.